Marine Ecosystems

SECTION 2

Objectives

- Explain why an estuary is a very productive ecosystem.
- Compare salt marshes and mangrove swamps.
- Describe two threats to coral reefs.
- Describe two threats to ocean organisms.

Marine ecosystems are ecosystems that contain salt water. Such ecosystems are found in and around the world's oceans. In the open water, the amount of sunlight and available nutrients vary from one part of an ocean to another. In coastal areas, the water level and salinity usually change during the day.

Key Terms

estuary
salt marsh
mangrove swamp
barrier island
coral reef

Coastal Wetlands

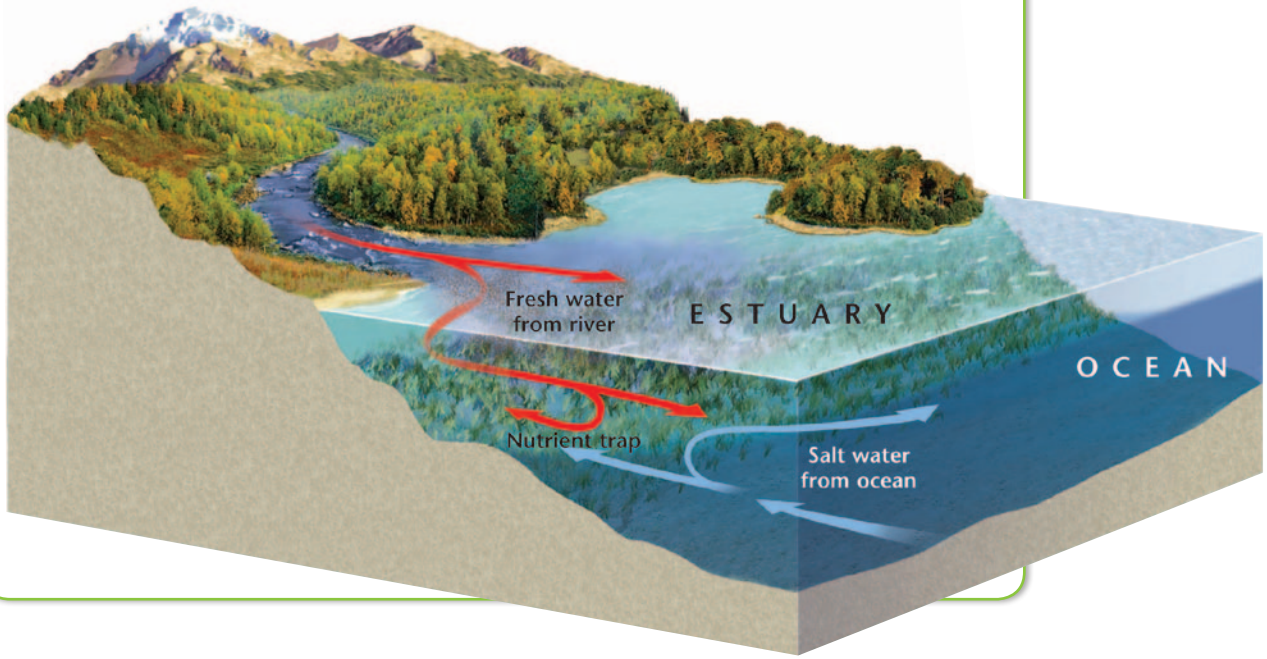
Coastal land areas that are covered by salt water for all or part of the time are known as *coastal wetlands*. Coastal wetlands provide habitat and nesting areas for many fish and wildlife. Coastal wetlands also filter out pollutants and sediments, protect shorelines from erosion, and provide recreational areas for boating, fishing, and hunting. Wetlands absorb excess rain, which protects areas from flooding: a crucial ecological service.

Estuaries

Many coastal wetlands form in estuaries. An **estuary** is an area in which fresh water from a river mixes with salt water from the ocean. As the two bodies of water meet, currents form and cause mineral-rich mud and dissolved nutrients to fall to the bottom. **Figure 2.1** illustrates how the waters mix in such a way that the estuary becomes a nutrient trap. These nutrients then become available to producers, and in some shallow areas, marsh grass will grow in the mud. Estuaries tend to be very productive ecosystems because they constantly receive fresh nutrients from the river. The surrounding land, such as the mainland or a peninsula, protects estuaries from the harsh force of ocean waves.

FIGURE 2.1

Estuary The mixing of fresh water and salt water at the mouth of a river creates a nutrient-rich estuary.



QUICKLAB

Estuaries

Procedure

1. Fill a clean fish bowl two-thirds full with tap water.
2. Pour 200 mL of ocean saline solution into a 250 mL beaker and add 5 drops of red food coloring.
3. Slowly pour the saline solution into the water in the bowl.
4. Record your observations.
5. Repeat using the estuary solution.

Analysis

1. What do your observations tell you about how fresh water and sea water interact in an estuary?
2. Why is this interaction so important to species that live in the estuary?

Plants and Animals of Estuaries

For a week each spring, horseshoe crabs, shown in **Figure 2.2**, crawl out of the ocean and onto the beaches of Delaware Bay. In the shallow areas along the shore, the crabs mate and lay billions of eggs. Many migrating shorebirds depend on these eggs for food.

Estuaries support many marine organisms because estuaries receive plenty of light for photosynthesis and abundant nutrients for plants and animals. Rivers supply nutrients that have been washed from the land, and because the water is shallow, sunlight can reach all the way to the bottom of the estuary. The light and nutrients support large populations of rooted plants as well as plankton. The plankton in turn provide food for larger animals, such as fish. Dolphins, manatees, otters, and other mammals often feed on fish and plants in estuaries. Oysters, barnacles, and clams live anchored to marsh grass or rocks and feed by filtering plankton out of the water. Organisms that live in estuaries are able to tolerate variations in salinity because the salt content of the water varies as fresh water and salt water mix when tides go in and out.

CASESTUDY

Restoration of the Chesapeake Bay

The Chesapeake Bay is the largest estuary in the United States. The bay produces large amounts of seafood each year, supports many species of wildlife, and provides recreation for millions of people.

However, the ecosystems of the bay are threatened by several environmental problems. Pollution builds up because only a very narrow opening joins the bay and the ocean. Because of this the small tide flushes pollutants out of the bay very slowly. By 1980, the Chesapeake Bay was severely polluted with toxic industrial chemicals. Pesticides as well as excess nutrients ran into the bay from housing developments, farms, and wastewater (including sewage). Marsh grasses and plankton were dying, and fish, oysters, and crabs were disappearing. Birds of prey, such as bald eagles, had almost vanished. Therefore, environmentalists and residents became alarmed and launched campaigns to save the bay.

Restoring Chesapeake Bay habitats and water quality is not easy. Maryland and Virginia, the main bordering states of the bay, have different environmental laws. Also, the bay's watershed covers parts of four other states. Interested groups would have to work together if they were to restore the bay. The Chesapeake Bay Program was set up as a partnership between the Environmental Protection Agency, the

The Chesapeake Bay forms where the Potomac, Rappahannock, and other rivers meet the Atlantic Ocean.

Estuaries provide protected harbors, access to the ocean, and connection to a river. As a result, many of the world's major ports are built on estuaries. Of the 10 largest urban areas in the world, 6 were built on estuaries. These 6 cities are Tokyo, New York, Shanghai, Buenos Aires, Rio de Janeiro, and Mumbai.

Threats to Estuaries

Estuaries in populated areas were often used as solid waste landfills. The landfills were then developed and used as building sites. This practice occurred widely in California, which now has plans to restore some of its estuary wetlands. The pollutants that damage estuaries are the same pollutants that damage other aquatic ecosystems: sewage, industrial waste, and runoff from agricultural, domestic, and urban sources. Most of these pollutants eventually break down over time, but estuaries cannot cope with the excessive amounts produced by dense human populations.

FIGURE 2.2

Estuary Life Horseshoe crabs go to the Delaware Bay, an estuary between New Jersey and Delaware, to lay their eggs.

This great egret lives in one of the estuaries that borders the Chesapeake Bay.

District of Columbia, Maryland, Pennsylvania, Virginia, and citizen advisory groups. Goals included reducing chemical pollution, removing dams that prevented fish from migrating, and reforesting river banks to reduce soil erosion.

Remarkable progress has been made in the last 30 years. As of 2010, around twenty-eight percent of the tidal waters that were analyzed showed no impairment from chemical contaminants. Blue crabs, for which the bay is famous, have rebounded from an average of 192 million in 1990 to 315 million in 2010. Planting trees has restored forested buffers to about 60 percent of the watershed, and populations of fish, such as striped bass, are increasing.

However, the number of people in the bay area is increasing and development is reducing forests at the rate of 100 acres per day. Also because of development, forested areas are becoming fragmented, reducing their ability to improve water quality and provide habitat for wildlife.

Concerned citizens have formed the Chesapeake Bay Program to study, preserve, and restore the bay's ecosystems. Many other parts of the United States have developed similar stewardship programs to protect their waterways.

Learn more about the watershed where you live and what you can do to help protect it. Participate in river, creek, and beach clean-ups and promote sustainable development in your community that will improve the future quality of life for people and the environment.

Critical Thinking

1. **Predicting Consequences** If the Chesapeake Bay Program had never been founded, what might have happened to the Chesapeake Bay? Select one organism and explain how it might have been affected.
2. **Identifying Relationships** How may the use of less fertilizer on plants and lawns help the Chesapeake Bay and other estuaries?

FIGURE 2.3

Mangroves Mangrove swamps are found along warm, tropical coasts and are dominated by salt-tolerant mangrove trees.

Salt Marshes

In estuaries, where rivers deposit their load of mineral-rich mud, **salt marshes** form. Here, thousands of acres of salt marsh support a community of clams, fish, and birds. The marsh also acts as a nursery in which many species of shrimps, crabs, and fishes find protection when they are small. As they grow to maturity and migrate to the sea, they are eaten by larger fish or caught by commercial fisheries. Salt marshes, like other wetlands, absorb pollutants and protect inland areas.

Mangrove Swamps

Mangroves, such as those shown in **Figure 2.3**, are several species of small trees adapted for growing in shallow salt water. Most mangroves have wide, above-ground root systems for support. Dense growths of mangrove trees in swampy areas called **mangrove swamps** are found in tropical and subtropical zones. Mangrove swamps help to protect the coastline from erosion and reduce the damage from storms. They provide habitat for about 2,000 animal species. Like salt marshes, mangrove swamps have been filled with waste or used for development projects in many parts of the world.

Rocky and Sandy Shores

Rocky shores have many more plant and animal species than sandy shores do. The rocks anchor seaweed and the many animals that live on it, such as sea anemones, mussels, and sponges. Life on sandy shores, although less diverse, is abundant in the water and in the sand and sediments. In the water and on land, animals are adapted to the effects of drying and exposure at low tide. At low tide, birds poke and prod about for animals that have not attached themselves firmly enough or buried themselves deeply enough to escape the tidal pull. **Barrier islands**, such as the one in **Figure 2.4**, often run parallel to sandy shores. These islands help to protect the mainland and the coastal wetlands from storms and ocean waves and often provide habitat for wildlife.

ECOFACT

Mangrove Swamps

Mangroves cover 180 billion square meters of tropical coastlines around the world. The largest single mangrove swamp is 5.7 billion square meters, located in the Sundarbans of Bangladesh. This single mangrove swamp provides habitat for the Bengal tiger and helps supply approximately 300,000 people with food, fuel, building materials, and medicines.

CHECK FOR UNDERSTANDING

Name two things that a salt marsh has in common with a mangrove swamp.

FIGURE 2.4

Barrier Islands This barrier island is located off the coast of Long Island, New York. Barrier islands are separated from the mainland and help protect the shore of the mainland from erosion.

CRITICAL THINKING

Explain How do barrier islands protect the main shoreline from erosion?

FIGURE 2.5

Coral Reefs Coral reefs are found in warm, shallow waters, where there is enough light for photosynthesis. Coral reefs support a great diversity of species.

Coral Reefs

Coral reefs are limestone ridges built by tiny coral animals called *coral polyps* and the algae that live inside them. Coral polyps secrete skeletons of limestone (calcium carbonate), which slowly accumulate and form coral reefs. Thousands of species of plants and animals live in the cracks of coral reefs, which makes coral reefs, like Australia's 1600-mile-long Great Barrier Reef, among the most diverse ecosystems on Earth.

Because reef-building corals live only in warm salt water where there is enough light for photosynthesis, coral reefs are found in shallow, clear tropical seas. **Figure 2.5** shows the locations of coral reefs. Only the outer layer of a reef contains living corals, which build their rock homes with the help of the photosynthetic algae that live within them. Some coral reefs have been building for hundreds of thousands of years. Corals, such as those shown in **Figure 2.6**, are predators that never chase their prey. Their stinging polyps capture small animals that float or swim close to the reef. Because of their convoluted shape, coral reefs provide a habitat for a magnificent variety of fish, snails, clams, sponges, anemones, and many other types of marine organisms.

Coral Reefs in Danger

Coral reefs are fragile ecosystems. If the surrounding water is too hot or cold for too long, or if it is too muddy, polluted, or high in nutrients, the algae that live in the corals will leave or die. As a result, the corals turn white, a condition called *coral bleaching*. If coral bleaching occurs often or long enough, coral animals and the reefs they build will die.

Since the twentieth century, bleaching events have been occurring more frequently, mainly due to human activities. About 50 percent of the world's coral reefs are now in danger of destruction. In addition, climate change, oil spills, and polluting runoff have been linked to the destruction of coral reefs. Overfishing also upsets the balance of a reef ecosystem by devastating fish populations. Because coral reefs grow slowly, a reef may not be able to repair itself when parts of it are stressed or destroyed.

FIGURE 2.6

Polyps Coral reefs (bottom) are built by tiny coral animals called coral polyps. The stinging polyps of fire coral (top) capture animals by poisoning them.

Oceans

Because water absorbs light, sunlight that plants can use for photosynthesis penetrates only about 100 m (330 ft) into the ocean. As a result, much of the ocean's life is concentrated in the shallow, coastal waters. Here, sunlight penetrates to the bottom and rivers wash nutrients from the land. Seaweed and algae grow anchored to rocks, and phytoplankton drift on the surface. Invertebrates and fish that feed on these plants are also concentrated near the shore.

Plants and Animals of Oceans

In the open ocean, phytoplankton grow only in areas where there is enough light and nutrients. As a result, the open ocean is one of the least productive of all ecosystems. Phytoplankton have buoyancy devices, such as oil bubbles, that prevent them from sinking into deep water, which is too dark for photosynthesis. The sea's smallest herbivores are the zooplankton, which live near the surface with the phytoplankton they eat. The zooplankton include jellyfish, tiny shrimp, and the larvae of fish and bottom-dwelling animals, such as oysters and lobsters. Fish feed on the plankton as do marine mammals such as whales.

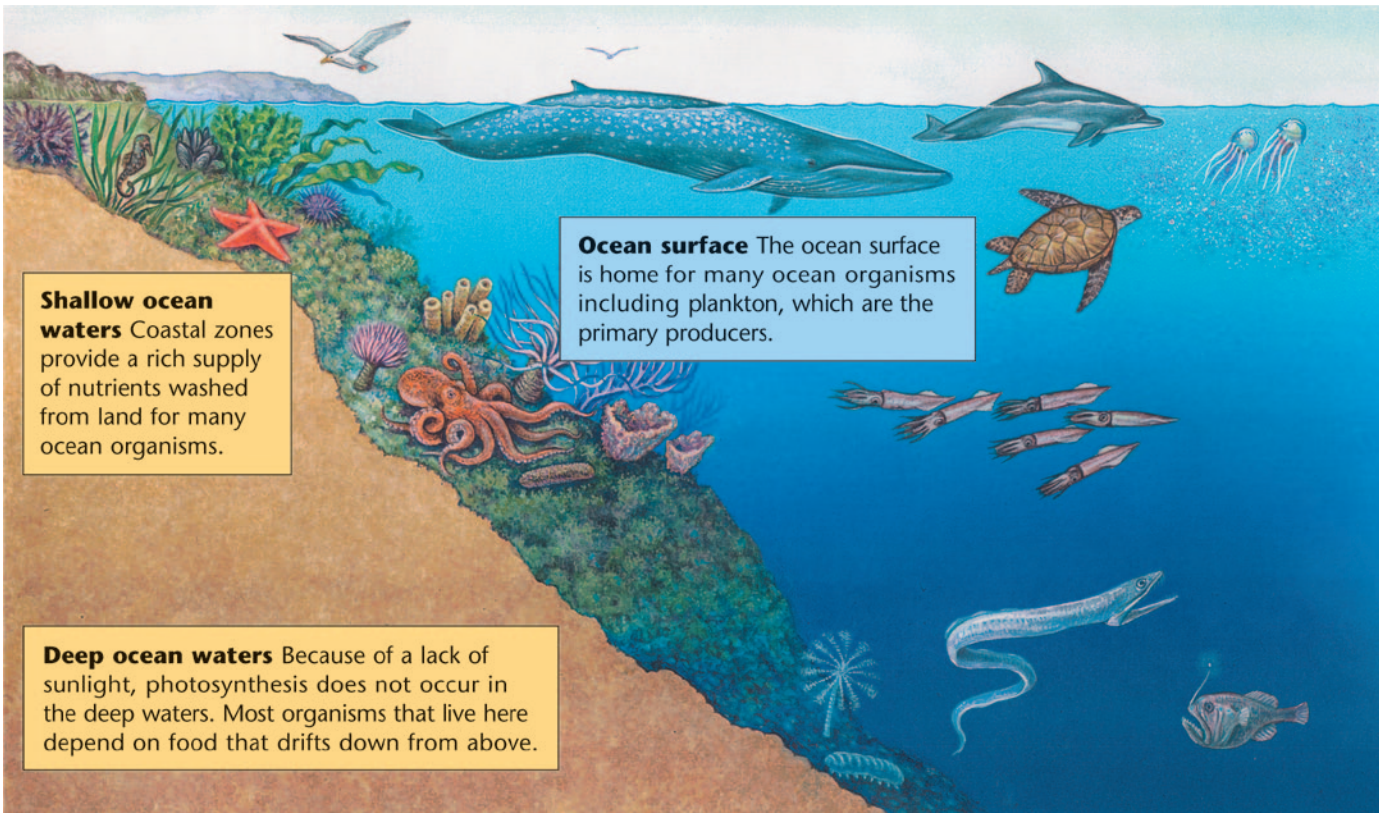
The depths of the ocean are perpetually dark, so most food at the ocean floor consists of dead organisms that fall from the surface. Decomposers, filter feeders, and the organisms that eat them live in the deep areas of the ocean, along with *chemosynthetic* organisms that derive nutrients from chemicals in the water or substrate. **Figure 2.7**

FIELDSTUDY

Go to Appendix B to find the field study **Once Upon a Time.**

FIGURE 2.7

Layers of the Ocean The amount of sunlight available determines which organisms can live in each layer of the ocean.



illustrates the types of organisms that may be found in the layers of the ocean at various depths, depending on available sunlight.

Threats to the Oceans

Although oceans are huge, they are steadily becoming more polluted. Most ocean pollution arises from activities on land. For example, runoff from fertilized fields, golf courses, or suburban lawns may cause algal blooms, some of which are poisonous. Waste from cities and industries, fertilizers, and sewage running off the land are the main sources of coastal pollution in the United States.

Overfishing and certain fishing methods are also destroying some fish populations. Immense trawl nets can entangle organisms that are larger than the holes in the nets. Marine mammals such as dolphins, and animals like sea turtles, which must breathe air, can drown in the nets if the nets are not equipped with escape mechanisms. Some ships illegally discard fishing lines into the ocean, where they can strangle and kill animals such as the sea lion in **Figure 2.8**.

FIGURE 2.8

Wildlife Threats This sea lion was strangled by a fishing net off the coast of California.

CHECK FOR UNDERSTANDING

What are two threats to organisms that live in the ocean?

Arctic and Antarctic Ecosystems

The arctic ecosystems at the North and South Poles are marine ecosystems because nearly all the food comes from the ocean and seas.

The Arctic Ocean is rich in nutrients from the surrounding land masses. It supports large populations of plankton, which feed a rich diversity of fish in the open water and under the ice. The fish are food for ocean birds, whales, and seals. Beluga whales, shown in **Figure 2.9**, feed on nearly 100 different arctic organisms. Fish and seals also provide food for polar bears and people on land.

The Antarctic is the only continent never colonized by humans. Even during the summer, only a few plants grow at the rocky edges of the continent. As in the Arctic, plankton form the basis of the Antarctic food web. They nourish large numbers of fish, whales, and birds such as penguins, which cannot fly because their wings have evolved for swimming.

FIGURE 2.9

Arctic Dweller Beluga whales inhabit the Arctic Ocean.

Section 2 Formative Assessment

Reviewing Main Ideas

1. **Explain** why estuaries are very productive ecosystems. Why are estuaries vulnerable to the effects of pollution?
2. **Compare** salt marshes with mangrove swamps.
3. **Describe** two factors that can damage coral reefs.
4. **List** two ways in which animals of the oceans are threatened.

Critical Thinking

5. **Predicting Consequences** Suppose that the sea level suddenly rose by 100 m. What would happen to the world's coral reefs? Explain.
6. **Analyzing Processes** Read the description of estuaries in this section, and explain why cities are often built on estuaries. How would building a city on an estuary affect the plants and animals living in the estuary?